Remediation of PCBs in buildings: Unsatisfying results as an effect of insufficient evaluation and planning

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Introduction

Polychlorinated Biphenyls (PCBs) are persistent organic compounds, which were widely used in buildings in the 1960s and 1970s. They were used as additive for elastic joint seals, wall paints, flame retardants in ceiling and anti-corrosive paints[1,2]. The broad use in public buildings such as schools and office buildings was not only limited on new buildings. Very often materials with PCB additives were applied for the renovation of old buildings as well. Depending on the installation, the PCBs polluted the indoor air. Beside the primary sources (industrial products with a PCB concentration of more than 1,000 mg/kg), secondary sources which have been contaminated during the years have to be considered. According to the PCB guidelines of various German Federal States (Laender), a decontamination of public buildings is mandatory. After restoration the concentration of PCBs in indoor air is not allowed to exceed 300 ng/m³. Decontamination programs in some communities started in the early nineties. Because of the lack of experience with regard to the decontamination of PCB buildings and the insufficient evaluation of PCB sources, the stipulations of the guidelines for PCB decontaminations very often have not been fulfilled. This, as a consequence, made a second remediation necessary which of course entailed additional costs. *Löthgren et al.*[3] described the use of high pressurized water for cleaning contaminated concrete as an example for a wrong remediation procedure. This paper deals with the remediation operations at an office tower as another example.

Methods

For monitoring the PCB concentrations during a remediation project, indoor air samples have been taken using transportable sampling equipment according to VDI guideline 3498 part 2[4]. A pump with a flow rate of 2.7 m³/h was used, sampling time was about two hours. The samples were adsorbed using polyurethane foam plugs (50 mm diameter, 100 mm thickness) filled in steel cartridges. The analysis of PCB was performed with GC/MSD-SIM using the following procedure:

The targets for analysis was the total PCB, expressed as the sum of 6 main PCB compounds (IUPAC# 28, 52, 101, 138, 153, and 180) multiplied by a factor of 5. After addition of a mixture of 6 $^{13}C_{12}$-labelled PCBs as internal standards, the PU plugs were extracted using hot Soxhlet extraction with toluene/acetone (10:1 v/v). A clean-up was performed if necessary (e.g. samples showing interferences or coloured extract) using SPE column chromatography (silica/sulfonic acid + silica/sulphuric acid cartridge combination). After clean-up and evaporation/concentration, another $^{13}C_{12}$-labelled PCB was added as a syringe standard for determination of the recovery rates. GC/MS-detection was performed on a 30 m DB5-column using an Agilent 6890/5973 HRGC-MSD-system in SIM-mode. Quantification was performed against the added internal standards using the isotope dilution method.

Initial situation

In an office tower (11 floors, see Figure 1) elastic joint seals with a PCB concentration of more than 100,000 mg/kg – especially the volatile congeners PCB 28, PCB 52 and PCB 101 – were found. The elastic joint seals were built in at window frames and between concrete pillars and walls. The PCB concentration in indoor air has been determined in several rooms with 4,000 up to 6,900 ng/m³. There was no investigation of secondary sources.

Figure 1: PCB-contaminated office tower

First remediation
The owner decided to perform a remediation in selected floors of the building to reduce the PCB concentration in indoor air. The elastic joint seals containing PCBs were cut out and new elastic joint seals (free of PCBs) were installed. For these works the window frames were not removed. The costs for one floor amounted to about 25,000 €. After this first remediation, the PCB concentration in indoor air was lowered to 250 - 550 ng/m³. It increased again to up to 2,000 ng/m³ within the two years following the first remediation.

Second remediation
As the first remediation did not result in a lasting reduction of PCBs in indoor air below 300 ng/m³, the reasons had to be determined. During the investigations, several building materials were removed, especially ceiling panels and window frames. Here the following PCB sources have been determined in the restored floors:

(1) With the disassembly of the window frames it became clear that it is not possible to remove the elastic joint seals which contain PCBs completely without removing the complete window frames. They are constructed with a rabbet inside, containing elastic joint seals with PCBs. These materials can only be removed by disassembly of the window frames (see Figure 2). In the restored floors the new elastic joint seals were contaminated by the old elastic joint seals inside the rabbet. Two years after installation the new elastic joint seals showed a PCB concentration of up to 20,000 mg/kg. This is in the range of the primary PCB sources built in in the sixties and seventies.
(2) The new elastic joint seals between concrete pillars and walls had a PCB concentration of up to 1,500 mg/kg. This again is in the range of primary PCB sources. The reason for this is the incomplete removal of the old elastic joint seals which contain PCBs.
(3) Contaminated wall paints and carpets with PCB concentrations of up to 100 mg/kg were identified as secondary sources for PCBs in the indoor air.

Based on the identified PCB sources, a second remediation was planned. The proceeding was elaborated by Eurofins│GfA in a detailed remediation concept. According to (1) it was most important to disassemble the window frames. The owner decided to dispose of the windows completely. According to (2) a complete removal of the elastic joint seals from concrete had to be guaranteed. Additionally, the walls (lightweight walls with contaminated wall paints) and ceilings had to be removed.

The following actions have been taken:

- Removal of carpets, lightweight walls and ceilings
- Deconstruction of windows and window frames
- Removal of all elastic joint seals at window frames and between concrete pillars and walls
- Grinding of concrete for complete removal of elastic joint seals
- Coating of concrete for fixing the dust
- rebuilding

After the second remediation the measurements on PCBs in indoor air showed significantly lower results. The PCB concentration were below 300 ng/m³. In 2007 i.e. two years after the second remediation (2005) the concentration of the main congeners PCB 28, PCB 52 and PCB 101 did not increase again (see Figure 4). The costs for one floor amounted to about 30,000 € (without rebuilding).

Conclusion

For sufficient results regarding the remediation of PCB contaminated buildings and for the lasting reduction of PCBs in indoor air, a complete removal of primary PCB sources is very important. The procedures for remediation have to guarantee that there is no carryover of PCB contaminations. Already small quantities of PCB-contaminated materials left in the building lead to a significant contamination of installed new materials. Thus, the reduction of PCBs in indoor air will not be long-lasting.

The experiences made by remediation of PCB contaminated buildings are also helpful in connection with the use of other persistent compounds in buildings, e.g. New POPs as Chlorinated Paraffins. Chlorinated Paraffins have the same appliance as additives for elastic joint seals[5]. They substituted PCBs and have a widely use in buildings and their relevance for indoor air quality is still in discussion.

References

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Figure 2: Window frame, rabbet with elastic joint seal containing PCB

Figure 3: View of a floor after second remediation

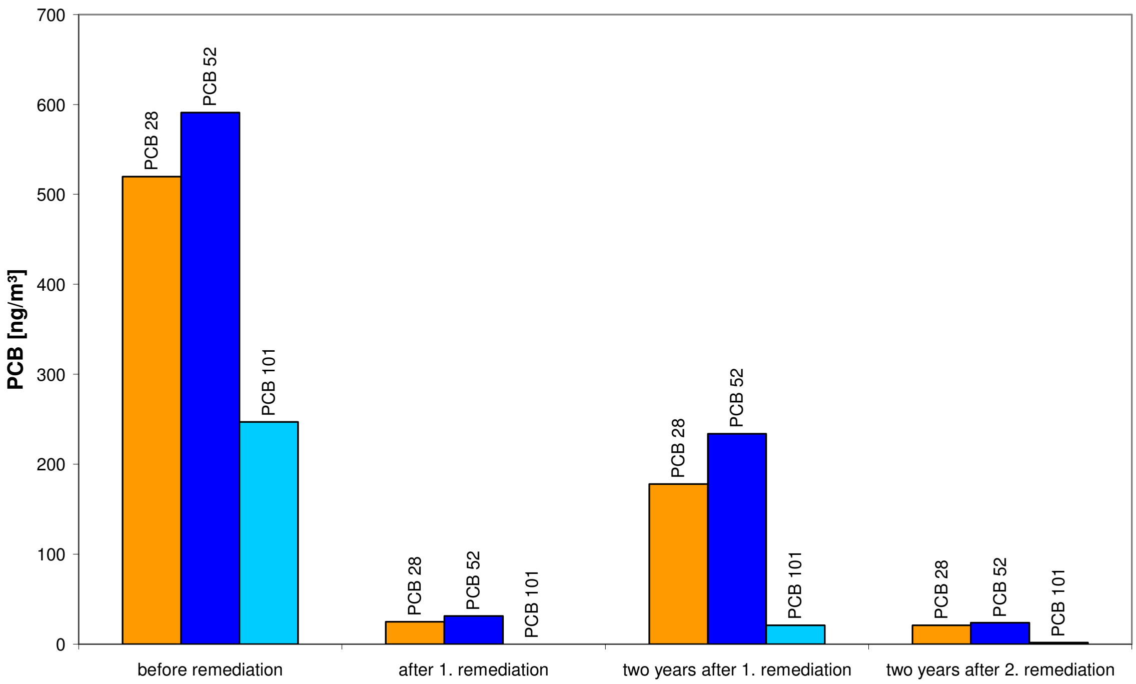

Figure 4: PCB concentration (main congeners) in indoor air at different phases of remediation